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Control of Hardwood Competition and Release of Softwood Regeneration on a Mixedwood Cutover in Western Newfoundland

J. Richardson

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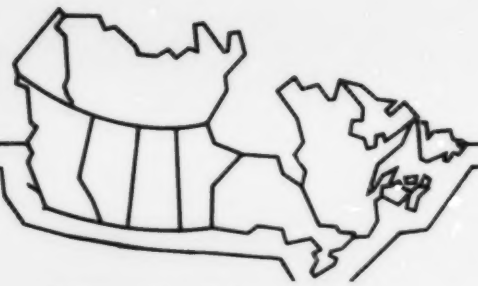
Newfoundland Forest Research Centre



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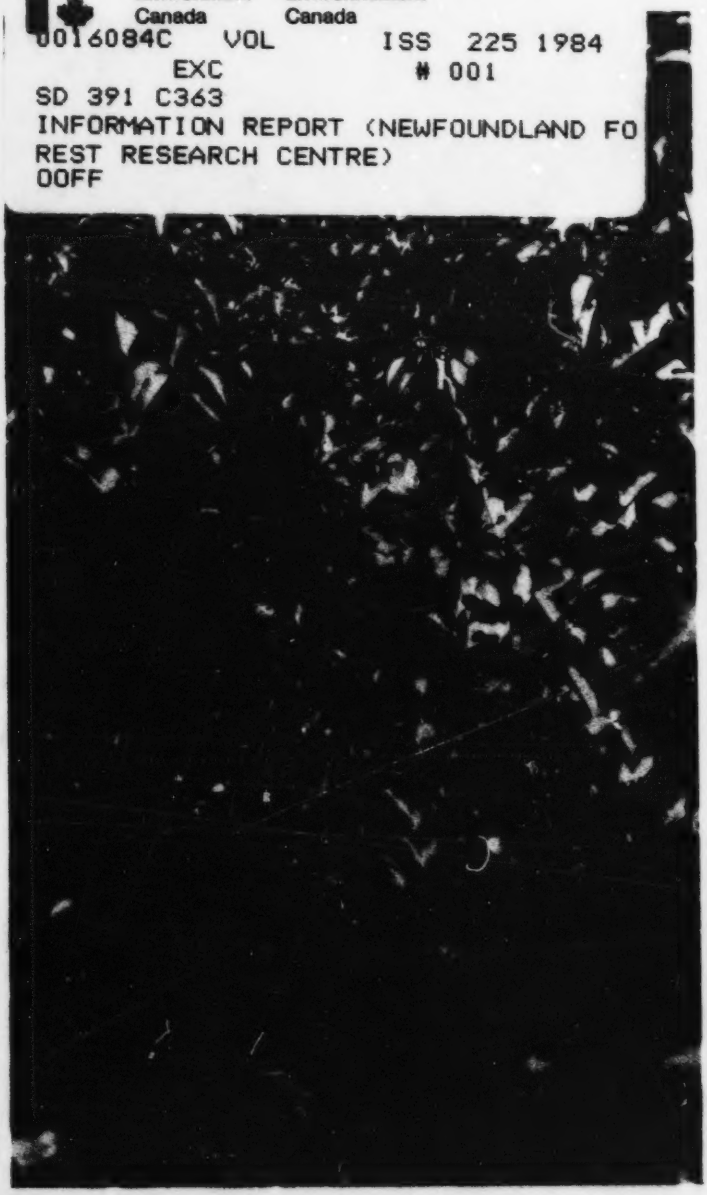

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CONTROL OF HARDWOOD COMPETITION AND RELEASE OF SOFTWOOD REGENERATION ON A MIXEDWOOD CUTOVER IN WESTERN NEWFOUNDLAND

by J. Richardson

INFORMATION REPORT N-X-225
1984

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ABSTRACT

An experiment was established to test methods of controlling hardwood brush competition and releasing softwood reproduction on a very productive mixedwood cutover site in western Newfoundland. Three chemical treatments - a mixture of 2,4-D and 2,4,5-T ('Brushkill'), triclopyr, and glyphosate - were compared with mechanical brushcutting. Two years after treatment, the herbicides gave much better control of the hardwoods than brushcutting; glyphosate was the most effective herbicide. All three herbicides caused some improvement in height growth of softwood reproduction, relative to hardwood growth, and relative to softwood height before treatment. The considerable variation in density and height of hardwoods and softwoods which existed at the start of the experiment tended to mask any differences between treatments. Recommendations are made with regard to the future of this experiment, and assessment techniques for future studies of this type.

RÉSUMÉ

On a fait une expérience pour vérifier les méthodes utilisées pour éliminer les broussailles feuillues et dégager les jeunes résineux, dans une station mixte très productive de l'ouest de Terre-Neuve qui avait été déboisée. Trois agents chimiques de traitement - un mélange de 2,4-D et de 2,4,5-T ("Brushkill"), le triclopyre et le glyphosate - ont été comparés à la coupe mécanique. Deux ans plus tard, la répression chimique avait donné de meilleurs résultats que la coupe, le glyphosate étant le plus efficace à ce titre. Les trois herbicides ont procuré une certaine amélioration de la croissance en hauteur des jeunes résineux par rapport à la croissance des feuillus et par rapport à leur hauteur initiale. La variation considérable en densité et en hauteur des feuillus et des résineux au début de l'expérience tendait à masquer toute différence entre les traitements. Des recommandations sont faites concernant le suivi de l'expérience et les techniques d'évaluation des études futures de ce type.

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INTRODUCTION

Hardwood species are a major component of the reproduction after harvesting in mixedwood stands in western Newfoundland. Balsam fir (Abies balsamea (L.) Mill.) and white birch (Betula papyrifera Marsh.) are the major tree species in these stands. Other tree and shrub species commonly present include mountain maple (Acer spicatum Lam.), pin cherry (Prunus pensylvanica L. f.), mountain ash (Sorbus americana Marsh.), yellow birch (Betula alleghaniensis Britt.), black spruce (Picea mariana (Mill.) B.S.P.) and white spruce (Picea glauca (Moench) Voss).

On these mixedwood cutovers, hardwood reproduction generally appears dominant over the softwood species. Richardson (1979) found that there are more hardwood stems than softwood in the regeneration on most of these sites and that the hardwoods are almost always taller. Whether the hardwoods are detrimental to softwood growth rates in Newfoundland has not been shown. Elsewhere in eastern Canada, however, Weetman et al. (1973) and Frisque et al. (1978) found brush and hardwood reproduction to be a major problem after pulpwood harvesting, though the problem was generally not evident till five years after cutting.

A number of investigators (Baskerville 1961, Hughes 1967, Lehela 1981) have shown that removing the brush and hardwoods has a beneficial effect on the growth of associated spruce and fir regeneration. The release can be achieved mechanically, by cutting the competition (Baskerville 1961), or chemically, by the use of herbicides (Hughes 1967, Lehela 1981).

Several chemical herbicides have been used to remove hardwood competition without causing damage to the softwood reproduction. The phenoxyacetic herbicides, chiefly 2,4-D and 2,4,5-T, have been widely used for 30 years (Sutton 1958, Arend 1959, Bunce 1979, Bentley & Estes 1978), but in recent years, the use of these chemicals, particularly 2,4,5-T, has been increasingly restricted by governments because of environmental concerns. A number of alternative herbicides have been developed recently and are being tested for forestry use. Triclopyr is an experimental herbicide which has given good control of hardwood and brush species without damage to young conifers in the Pacific Northwest (Gratkowski et al. 1978), France (Morel 1977) and Sweden (Bärring 1979). Glyphosate has been widely tested with considerable success in releasing softwood regeneration from hardwood competition (Sutton 1978, McCormack & Newton 1980, Lund-Høie 1977).

An experiment was established in western Newfoundland to compare the efficacy of three different chemical treatments (2,4-D + 2,4,5-T, triclopyr and glyphosate) and brushcutting as means of releasing

softwood regeneration from hardwood competition on a highly productive cutover site. The treatments were applied in 1978. Richardson (1980) described the establishment of the experiment and reported the initial effects of the treatments on the competition. Chemical treatments reduced hardwood stem densities much better than mechanical brushcutting which stimulated profuse regrowth of the hardwoods. Glyphosate gave the best immediate control of most hardwood species. Only minor temporary damage to softwood seedlings was recorded.

The experiment was remeasured in August 1980 after height growth ceased for the season. The objectives of this remeasurement were to record the effects of the treatments two years after application and to determine if softwood growth rates had improved as a result of treatment. This paper reports the results of these investigations.

MATERIAL AND METHODS

The experiment is located in the South Brook valley in western Newfoundland about 25 km east of the city of Corner Brook in Forest Section B.28b (Rowe 1972). It is situated in the middle of a moderately-steep, east-facing slope. The soil is a fresh to moist stony loam whose detailed characteristics were listed in the earlier report (Richardson 1980).

The previous stand, in which balsam fir and white birch predominated, was harvested for pulpwood in 1969. Subsequent reproduction was chiefly of balsam fir, white birch and pin cherry. In the young stand, hardwoods were distributed more evenly than the balsam fir

seedlings, but neither hardwoods nor softwoods had a uniform distribution. At the time of establishment of the experiment, the hardwoods averaged 1.0 to 1.5 m tall, while the softwood species were only about 0.5 m tall. Ground vegetation was dominated by dense raspberry (Rubus idaeus L.) and fireweed (Epilobium angustifolium L.) about 0.8 m tall. Richardson (1980) provides details of vegetation measurements made in 1977, prior to treatment.

The experiment has a randomized complete block design with four replications of each of five treatments:

1. 'Brushkill' - a mixture of 2,4-D and 2,4,5-T (1.4 kg active ingredient (a.i.)/ha of each in amine form in about 700 ℓ water/ha) applied as foliage spray by mistblower.
2. Triclopyr - 'Garlon 3A[1]'(1.9 kg a.i./ha in triethyl amine form in about 700 ℓ water/ha) applied as foliage spray by mistblower.
3. Glyphosate - 'Roundup[2]' (2.25 kg a.i./ha in about 400 ℓ water/ha) applied as foliage spray by mistblower.
4. Brushcutting - mechanical cutting of all hardwood stems and tall ground vegetation.
5. Control - no treatment.

Each treatment was applied to plots of 0.1 ha (25 m x 40 m) (Figure 1). 'Brushkill' and triclopyr were applied in early July 1978

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[1]Registered trademark of Dow Chemical Company.

[2]Registered trademark of Monsanto Company.

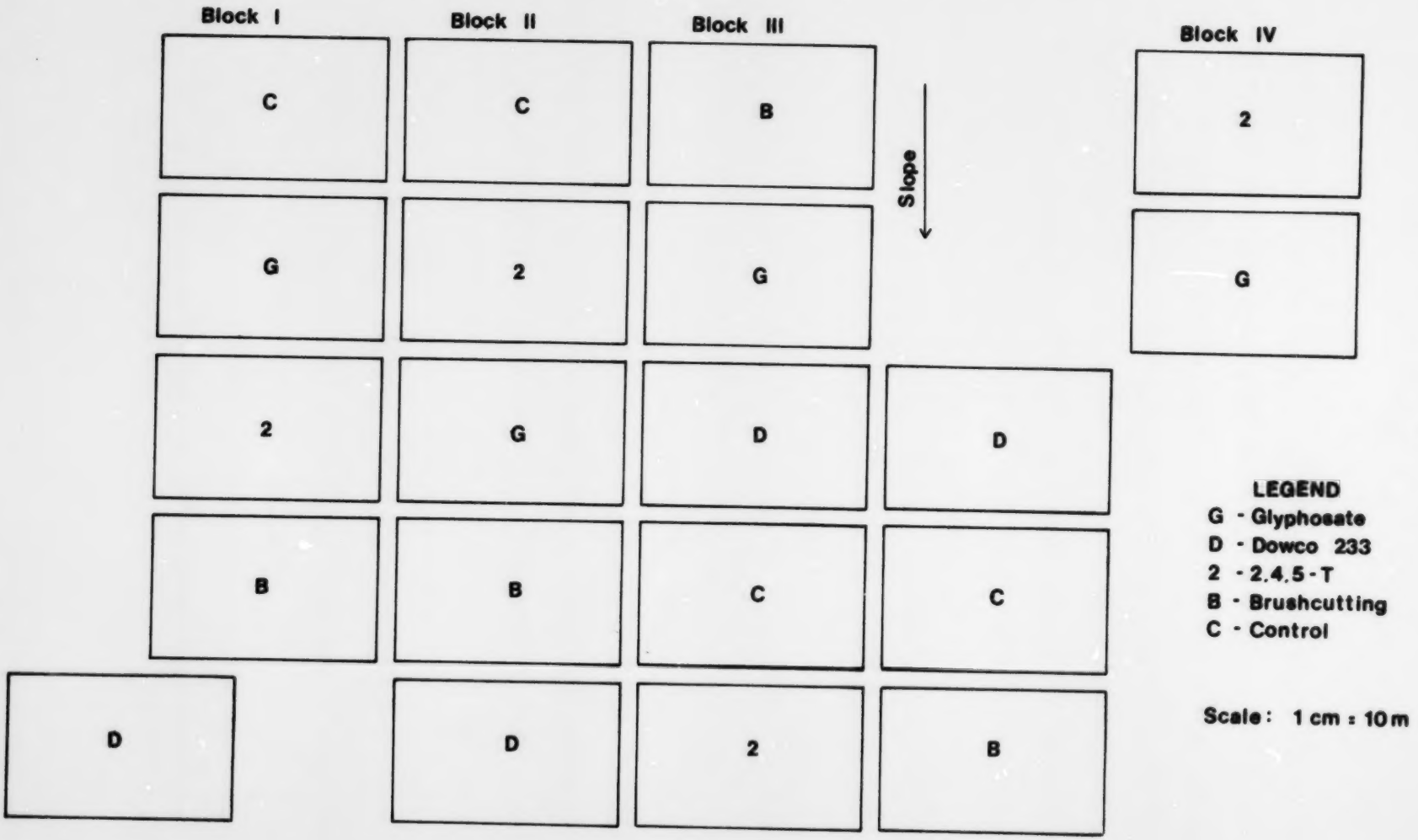

Figure 1. Layout of experimental plots

about the time of peak hardwood growth. Glyphosate was applied in late August 1978 after hardwood growth for the year was complete. Chemical application dates and rates were selected on the basis of the manufacturers' recommendations to give maximum control of the hardwoods with minimum damage to the softwoods. Brushcutting was carried out also in late August 1978. Details of treatment application and associated weather conditions are reported by Richardson (1980).

Within each treatment plot, a line of 15 permanent 4 m^2 (2 m x 2 m) quadrats was established parallel to the long axis of the plot, at a location selected at random from 16 possible locations. All sample quadrats were contained within a 5 m border strip around each plot.

Measurements of treatment effects were made only on the sample quadrats. In 1977, prior to treatment, the total height of every stem of each woody species, and the 1977 leader length of softwood stems were recorded. For multi-stemmed species, individual stems were counted at 15 cm above ground level. Total cover and average height of ground vegetation within each quadrat were recorded and ground vegetation species which covered more than 10 percent of each quadrat were listed.

In mid-July 1979, one year after treatment, the first five quadrats in each line of 15 were examined for condition (mortality, defoliation, other damage) of each woody species stem, and cover and species of herbaceous vegetation. Results of this remeasurement have been previously reported (Richardson 1980).

In mid-August 1980, all 15 sample quadrats in each plot were remeasured to determine the effects of the treatments two years after application. The total height of every stem of each woody species and the 1980 leader length of softwood stems were recorded. Ground vegetation species with cover more than 10 percent of each quadrat were recorded, as well as total cover and average height of the ground vegetation in each quadrat.

Data from the 1977 and 1980 surveys were compiled, tabulated and, where appropriate, subjected to analysis of variance in accordance with standard statistical procedures for the randomized complete block design. Differences between means were tested for significance using Tukey's W procedure. Direct statistical comparisons were made between 1977 and 1980 data by considering the experiment as a 'split-plot in time' (Steel and Torrie 1960).

Many of the statistical comparisons which were made showed a lack of significance due to the great amount of variability in height and density from plot to plot. For this reason, only where differences are statistically significant are the results of the statistical analysis discussed in detail.

RESULTS AND DISCUSSION

a. Effects of treatments on hardwoods

Hardwood stem densities before and after treatment are shown in Figure 2 and the percentage changes in density (calculated as [1980

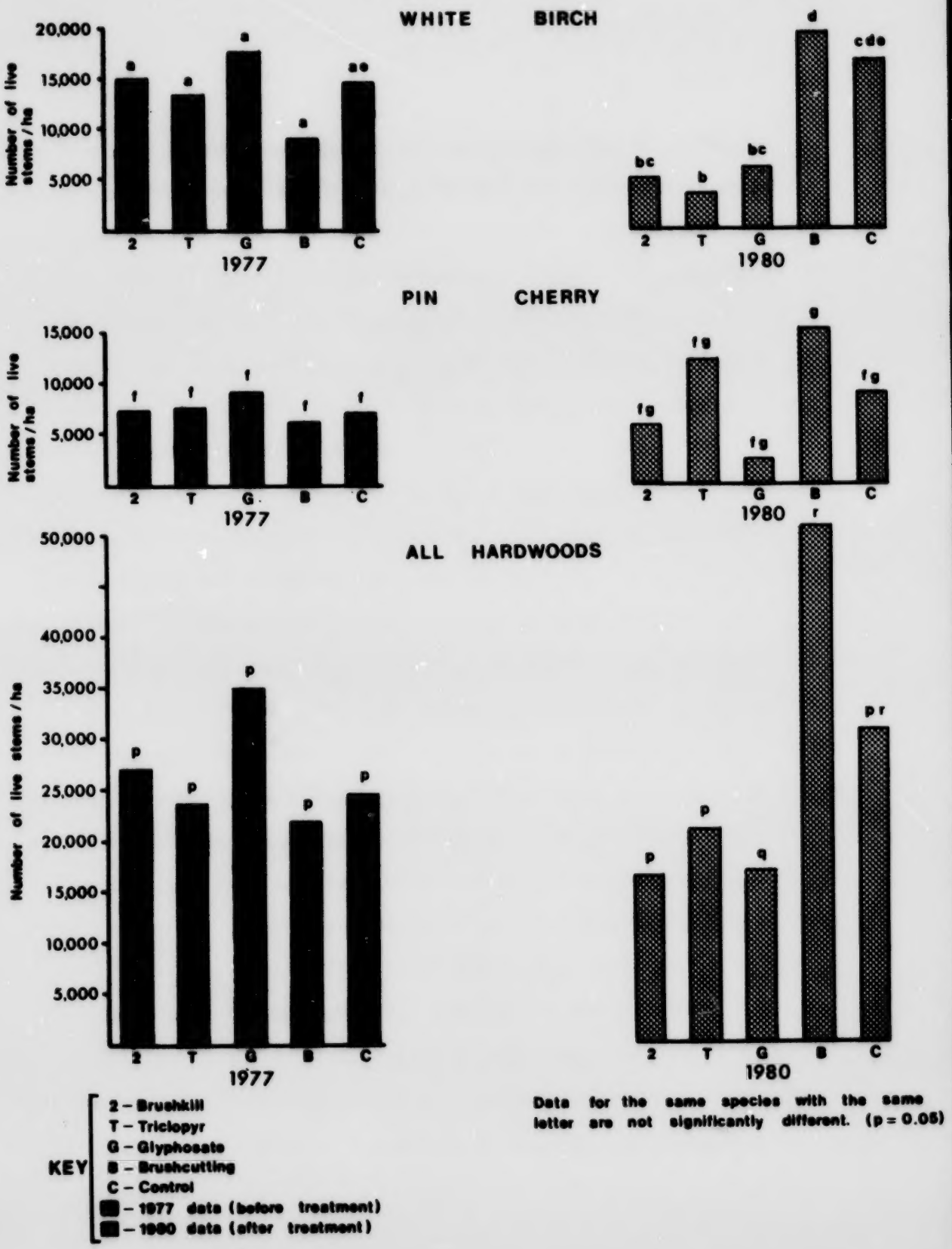

Figure 2. Hardwood stem densities before and after treatment

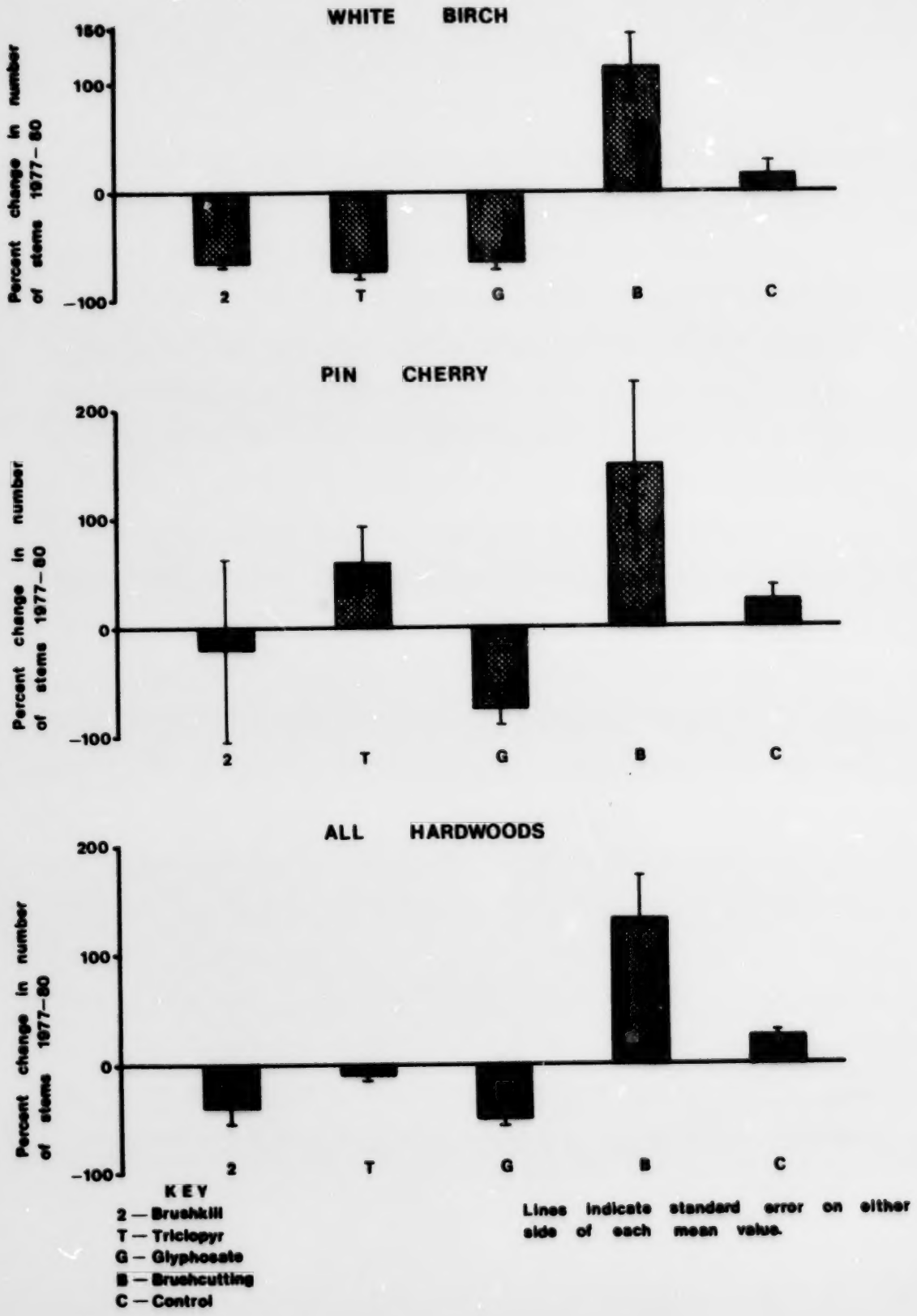

Figure 3. Change in hardwood stem densities following treatment

density - 1977 density] x 100/1977 density) are shown in Figure 3. Generally, the untreated plots had a small (25 percent), but not significant, increase in live hardwood stems. On herbicide-treated plots, live hardwood stem density decreased; the decrease was greatest on glyphosate-treated plots where there were fewer than half as many live hardwood stems in 1980 as in 1977. However, only on glyphosate plots was the density in 1980 significantly less than in 1977. Brushcutting, on the other hand, resulted in a 134 percent increase in hardwood stems. This increase was significant, though the increased density was not significantly greater than the density on untreated plots in 1980. Clearly, the herbicides gave better hardwood control than mechanical brushcutting and glyphosate was the most effective of the three herbicides.

After all three herbicide treatments, white birch live stem densities were significantly reduced. However, only triclopyr plots had significantly fewer white birch stems in 1980 than the untreated plots.

Results with pin cherry were variable. After 'Brushkill' and glyphosate treatment, pin cherry densities were reduced, but non-significantly. After triclopyr treatment there were 61 percent more cherry stems. The absence of significant herbicide effect on pin cherry may be due to the 'buried seed' strategy of this species (Marks 1974). Pin cherry seeds are known to lie dormant in upper soil layers for many years until disturbance creates conditions suitable for germination.

Alder (Alnus sp.) and mountain maple were the most common of the other hardwood species. None of the treatments had much effect in reducing the densities of those species, with the exception of glyphosate which caused a 70 percent reduction in live mountain maple stems.

The results confirm in general terms the findings of the 1979 partial remeasurement (Richardson 1980). The reductions in overall hardwood stem densities reported here are not as great as reported previously, but glyphosate is confirmed as the most effective treatment in providing hardwood control. The 1980 data showed that glyphosate gave better control of mountain maple than was suggested by the 1979 data.

b. Effects of treatments on softwoods

Average height and leader length of all balsam fir stems were greater in 1980 than in 1977 for all treatments (Figure 4). The greater leader lengths may be attributed to better weather conditions for growth in 1980.

Among the various treatments, including control, there were no significant differences in balsam fir average height or leader length in either 1977 or 1980. However, Figure 4 shows that in 1980 fir height was greatest after 'Brushkill' and triclopyr treatment; leader length was greatest after triclopyr treatment. The height relationships among treatments in 1980 were generally similar to those prevailing in 1977.

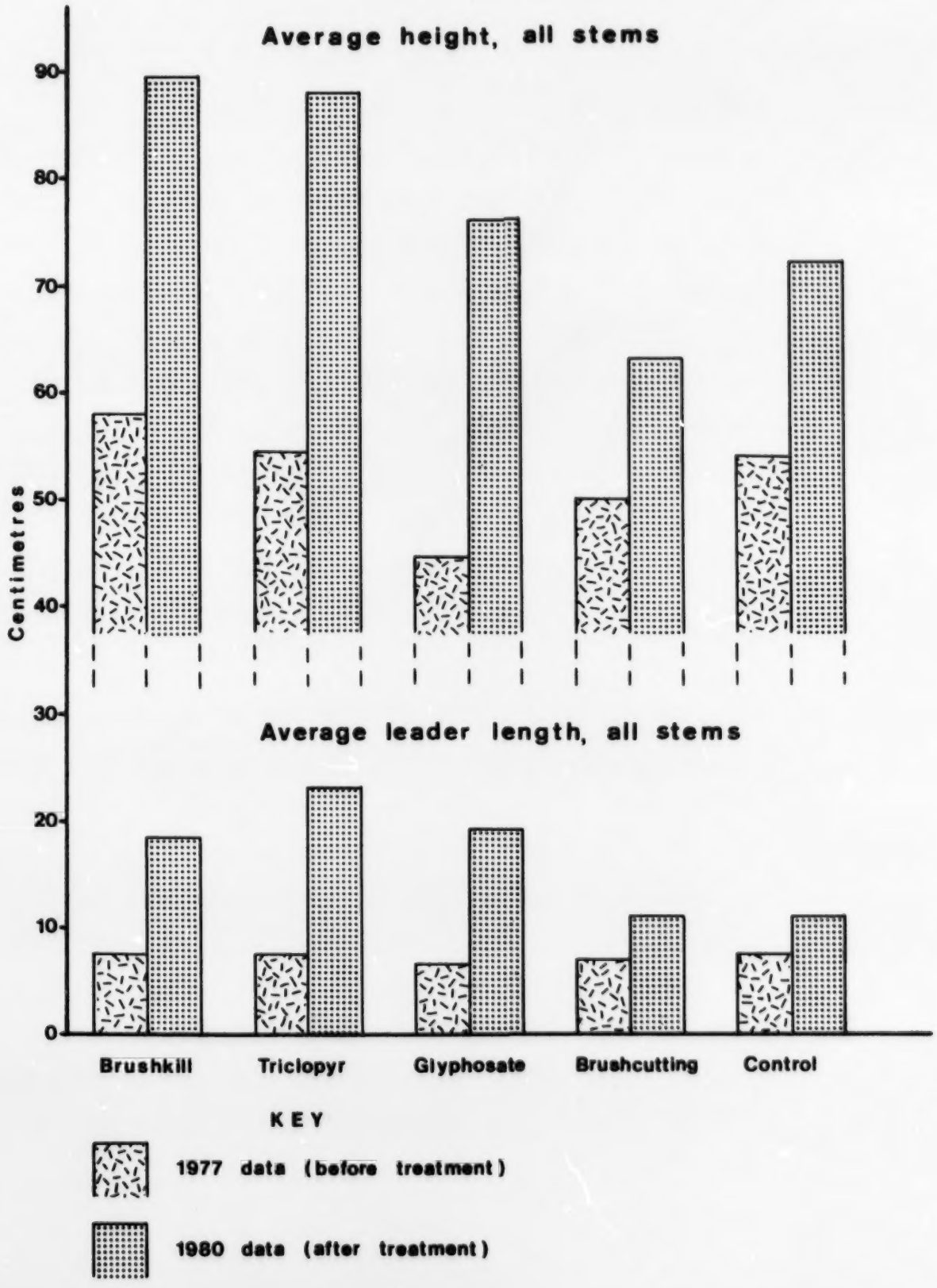

Figure 4. Average height and leader length of all Balsam Fir stems before and after treatment

The absence of statistical significance in the differences between treatments, despite obvious differences in average height and leader length (e.g., average fir leader length in 1980 in triclopyr-treated plots was 47 percent greater than in control plots) must be attributed to the considerable variation in average height of balsam fir within the experimental area. This pre-existing variation masked any direct differences in height growth which may have been caused by the treatments.

Expressing the change in average balsam fir height and leader length between 1977 and 1980 as a percentage of the 1977 figures, as in Figure 5, compensates for the initial height variation and makes treatment effects clearer. This percentage change can be referred to as relative growth. Relative height growth of fir was greater in herbicide-treated plots than in brushcut or control plots. There was virtually no difference in relative fir height growth among the three herbicide treatments. For relative leader growth of fir, the pattern was similar, but the difference between herbicide treatments and the other treatments was much greater. This is clear evidence of 'release growth' attributable to the herbicide treatments. The 1980 fir leader growth in herbicide-treated plots was almost three times what it had been in 1977, whereas in brushcut and control plots, the 1980 leaders were only half as tall again as in 1977.

With the clear improvement in relative leader growth of fir now evident, it is possible that future remeasurements of this experiment

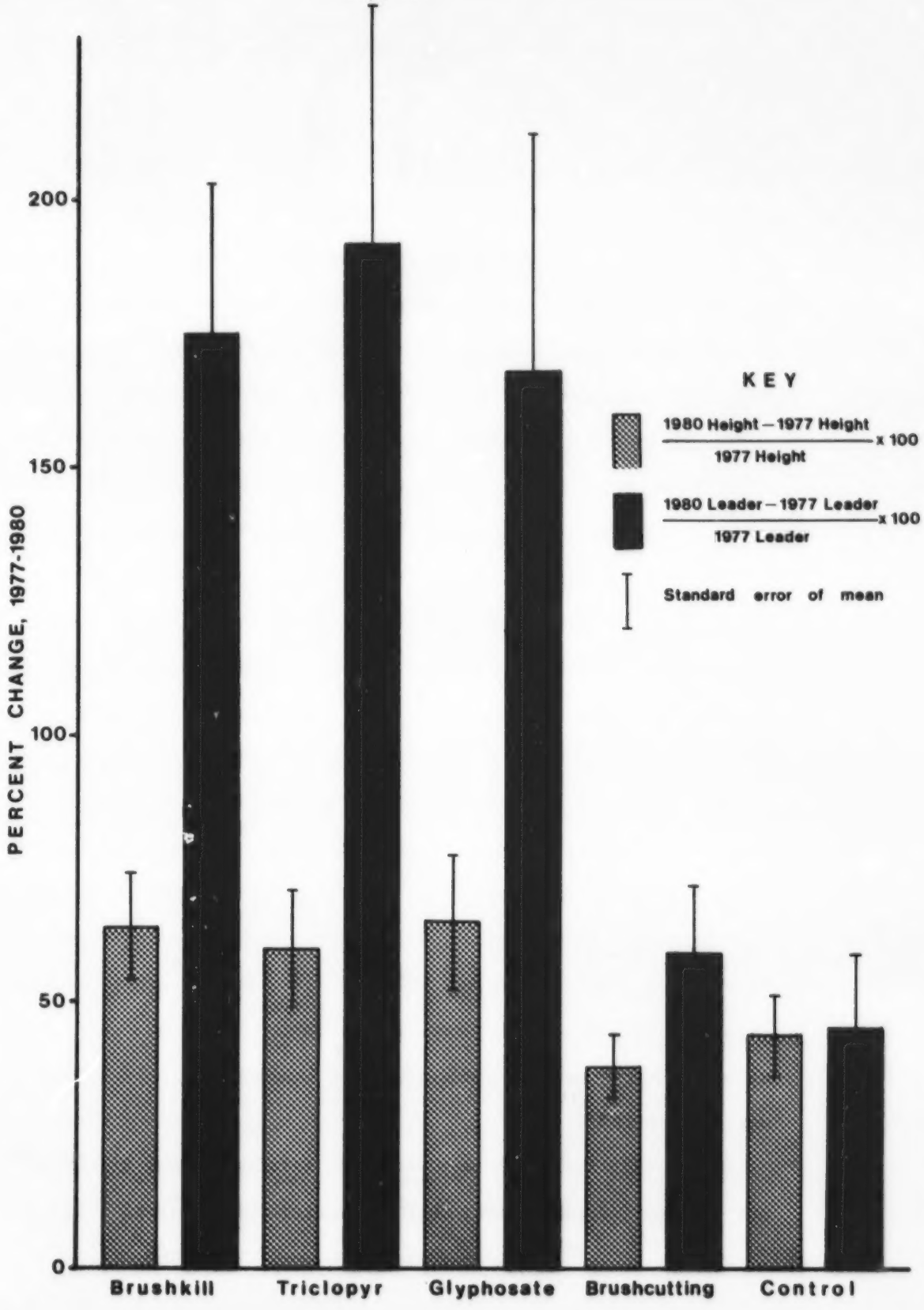

Figure 5. Percent change in Balsam Fir height and leader length following treatment

may show significant absolute height differences between herbicide-treated and other plots. Lehela (1981) reports improvements in balsam fir total height and five-year height increment of 19-51 and 29-163 percent respectively in the first five years after aerial spraying of phenoxy herbicides on northern Ontario cutovers. After applying glyphosate aerially to Norway spruce (Picea abies (L.) Mill.) plantations suffering from birch and aspen competition in Sweden, Lund-Høie (1980) found an increase in spruce height growth compared to untreated controls of 20-30 percent after two years and up to about 50 percent after five years.

Measuring the height growth of the softwood stand following various release treatments and comparing it with height growth before treatment or in untreated plots is one way of determining the effectiveness of the treatments in providing release from competition. Another method of determining release is to compare the height of the hardwood competition relative to the height of the softwood stand before and after treatment. In Figure 6, average height of all balsam fir stems is shown as a percentage of the average height of all hardwood stems for each treatment, in 1977 and in 1980. This shows that while the average fir stem had not outgrown the average hardwood stem by 1980, it had considerably improved its position in the overall stand in all treated plots. The improvement (1977-80) was greatest in triclopyr-treated plots; it was about equal in Brushkill- and glyphosate-treated and on brushcut plots. A small improvement is evident in untreated plots

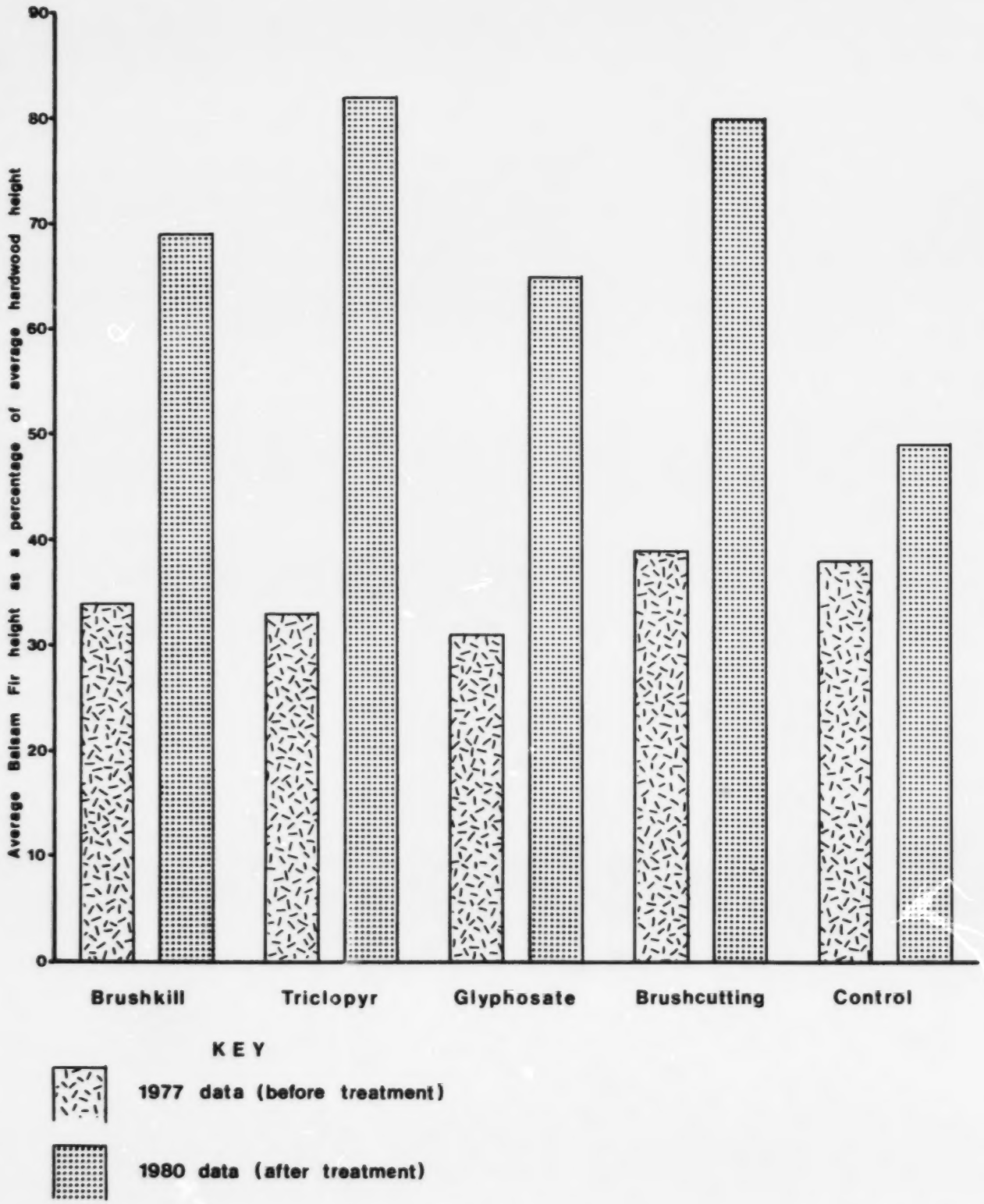

Figure 6. Relative heights of Balsam Fir and hardwood stems before and after treatments

suggesting the possibility that the fir might eventually outgrow the competition unaided. However, at present growth rates, this would take many years.

A comparison of Figures 2, 5 and 6 illustrates the difference between the effects of the brushcutting and the effects of the herbicides. Brushcutting temporarily removed all hardwood stems, but they immediately began to sprout profusely (Figure 2), and by 1980 had outgrown the fir slightly (Figure 6). However, the intense competition for soil moisture and nutrients created by the hardwood regrowth may have prevented the fir from improving its growth rate over that of fir on the untreated plots (Figure 5). On the other hand, the herbicide treatments, while not completely eliminating the hardwoods (Figure 2, 6), reduced their numbers (Figure 2) and vigour considerably. Thus the fir stems on herbicide-treated plots were able to benefit from the reduction in competition and improve their growth rate much more than fir on brushcut or untreated plots (Figure 5).

The lack of statistically significant improvements in fir growth in the two growing seasons after treatment has been attributed to the considerable pre-existing variation in fir height. It is also possible that two growing seasons after treatment are not sufficient time for the development of a full expression of release growth. To investigate this possibility, the experiment will be remeasured after another three or four growing seasons have elapsed. At that time, as well as height growth, diameter growth will be measured using ring analysis techniques on disks taken from cut stems. Other studies have

shown that softwood diameter growth response to herbicide treatment of competition is as great as or much greater than height growth response (Allan et al. 1978, Lehela 1981).

Diameter growth is also one of the chief response criteria recommended for use by Walstad and Wagner (1982) in a recently-published experimental design manual for studies of release of young conifer stands from uniformly-distributed brush competition. This manual also recommends the use of a single pre-selected typical conifer specimen on each sub-plot for assessment of release effects. This approach is more statistically satisfactory than measuring all stems as in the present study, and is recommended for future studies of this type.

c. Effects of treatments on herbaceous cover

Richardson (1980) reported decreases in cover of live herbaceous vegetation of up to 45 percent after herbicide treatments. The greatest decrease was on plots treated with triclopyr. By 1980 the herbaceous vegetation cover had been restored to its original level with the exception of a slight (but non-significant) reduction in the case of triclopyr (Table 1). In 1979, herbaceous cover on brushcut plots was slightly greater than before treatment. By 1980, it had returned to pre-treatment levels here also. Evidently the treatments had only a temporary effect on the herbaceous cover.

Only minor changes in herbaceous species composition occurred. A slight decrease in the occurrence of fireweed was associated with the herbicide treatments. In some triclopyr-treated plots a small influx of grasses was observed.

Table 1. Effects of treatments on herbaceous cover.

Year	Percent Cover of Herbaceous Vegetation, by Treatment				
	'Brushkill'	Triclopyr	Glyphosate	Brushcutting	Control
1977	60	56	64	76	66
1980	58	42	69	76	58

CONCLUSIONS

Chemical herbicides gave much better control of reproduction of unmerchantable hardwood species on this highly productive mixedwood cutover than did brushcutting. Glyphosate gave better control of most hardwood species than either 'Brushkill' or triclopyr. However, triclopyr gave the best control of white birch. Mountain maple was controlled more effectively by glyphosate than by the other herbicides. Brushcutting caused a considerable increase in numbers of hardwood stems. These findings, from measurements made two years after treatment, confirm the results of earlier preliminary measurements (Richardson 1980). The treatments had only a temporary effect on herbaceous cover which had almost returned to pre-treatment conditions within two years.

The herbicide treatments caused some increase in height growth of balsam fir reproduction but no statistically significant increases were found. All three herbicide treatments increased average fir height growth relative to what it had been before treatment, more than either brushcutting or no treatment. On average, the fir did not

outgrow the hardwoods. However, average fir height increased relative to that of the hardwoods after all herbicide treatments and brushcutting, but particularly after the triclopyr treatment.

The analysis of the results of this experiment was affected by the large variation which existed at the start of the trial in density and height of hardwoods and fir. It is recommended that in future studies of this type, the number of stems on which measurements are made be reduced to one typical specimen of each conifer and brush species in each subplot. It is further recommended that the present study be continued to determine if significant differences in softwood height growth develop between treatments, and that future remeasurements include investigations of softwood diameter growth since treatment.

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